US009790827B2

(12) **United States Patent**
Yamada et al.

(10) **Patent No.: US 9,790,827 B2**
(45) **Date of Patent: Oct. 17, 2017**

(54) **POSITIVE CRANKCASE VENTILATION ("PCV") VALVE MOUNTING STRUCTURE**

(71) Applicant: **AISAN KOGYO KABUSHIKI KAISHA**, Obu-shi, Aichi-ken (JP)

(72) Inventors: **Shigeki Yamada**, Nagoya (JP); **Masahiro Kida**, Nagoya (JP)

(73) Assignee: **AISAN KOGYO KABUSHIKI KAISHA**, Obu-Shi, Aichi-Ken (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 106 days.

(21) Appl. No.: **14/923,936**

(22) Filed: **Oct. 27, 2015**

(65) **Prior Publication Data**

US 2016/0123199 A1 May 5, 2016

(30) **Foreign Application Priority Data**

Nov. 4, 2014 (JP) 2014-224163

(51) **Int. Cl.**
F01M 13/00 (2006.01)

(52) **U.S. Cl.**
CPC . ***F01M 13/0011*** (2013.01); *F01M 2013/0038* (2013.01)

(58) **Field of Classification Search**
CPC F02M 35/10222; F02M 35/10078; F02M 35/10144; F02M 35/10255; F02M 35/10229; F02M 35/10354; F01M 13/022; F01M 13/00; F01M 13/028; F01M 2013/0083; F01M 2013/0044; F02D 2250/08
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,880,538	B2 *	4/2005	Ishizuka	F01M 13/0416 123/572
7,789,066	B2 *	9/2010	Torii	F02D 9/103 123/336
8,171,913	B2 *	5/2012	Sano	F02D 9/02 123/184.56
8,955,501	B2	2/2015	Tanikawa et al.	
2008/0099000	A1 *	5/2008	Suzuki	F01M 13/0011 123/574
2011/0203559	A1 *	8/2011	Tanikawa	F01M 13/023 123/572

(Continued)

FOREIGN PATENT DOCUMENTS

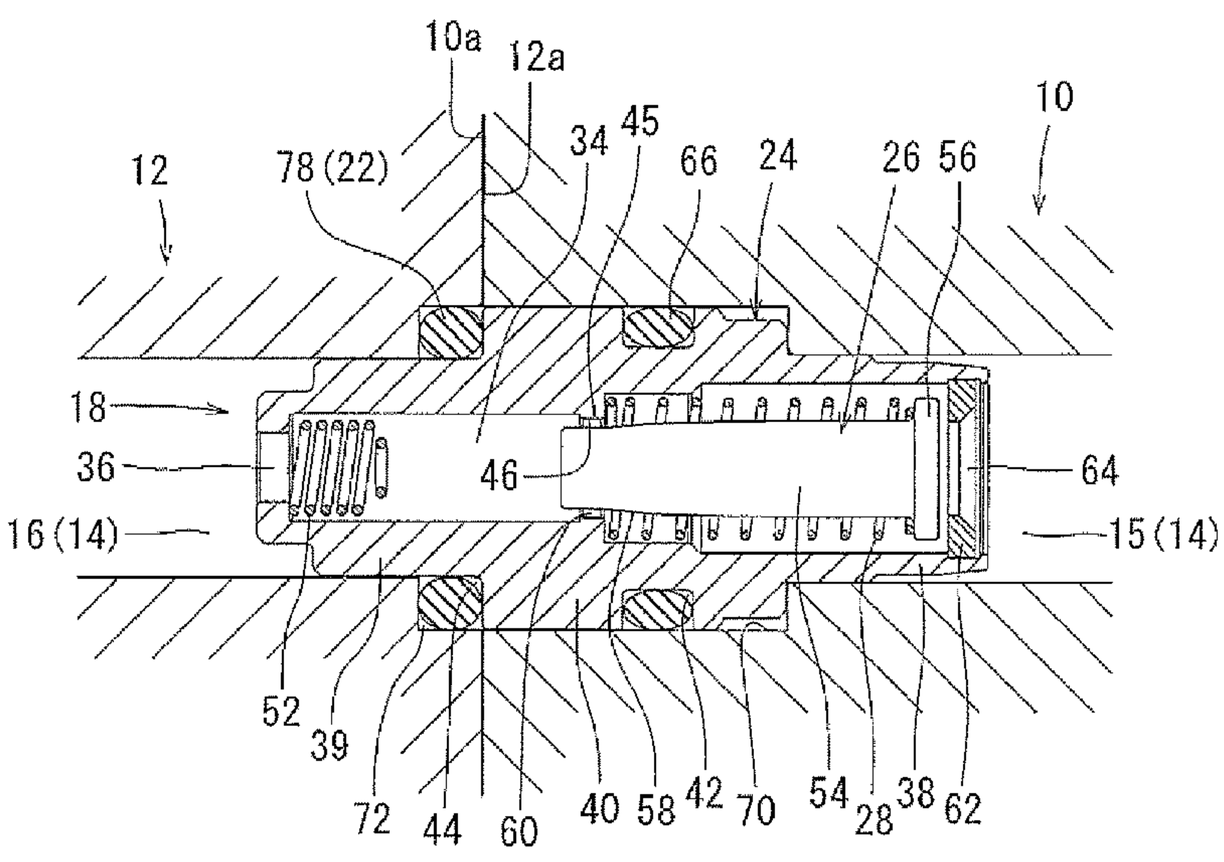
JP 2011-169258 A 9/2011

Primary Examiner — Long T Tran
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

A positive crankcase ventilation (PCV) valve mounting structure has a blow-by gas passage with an upstream-side passage portion and a down-stream-side passage portion positioned in a cylinder head and an intake manifold, respectively. The blow-by gas passage may receive the PCV valve therein such that an upstream side portion of a valve case of the PCV valve is positioned within the upstream-side passage portion and that a downstream side portion of the valve case is positioned within the down-stream-side passage portion when the cylinder head and the intake manifold are joined together. A gasket may seal the cylinder head to the intake manifold and may include a seal portion positioned between the valve case of the PCV valve and at least one of the cylinder head and the intake manifold.

12 Claims, 3 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2013/0213370	A1*	8/2013	Shirabe	F01M 5/002 123/574
2015/0114369	A1	4/2015	Tanikawa et al.	

* cited by examiner

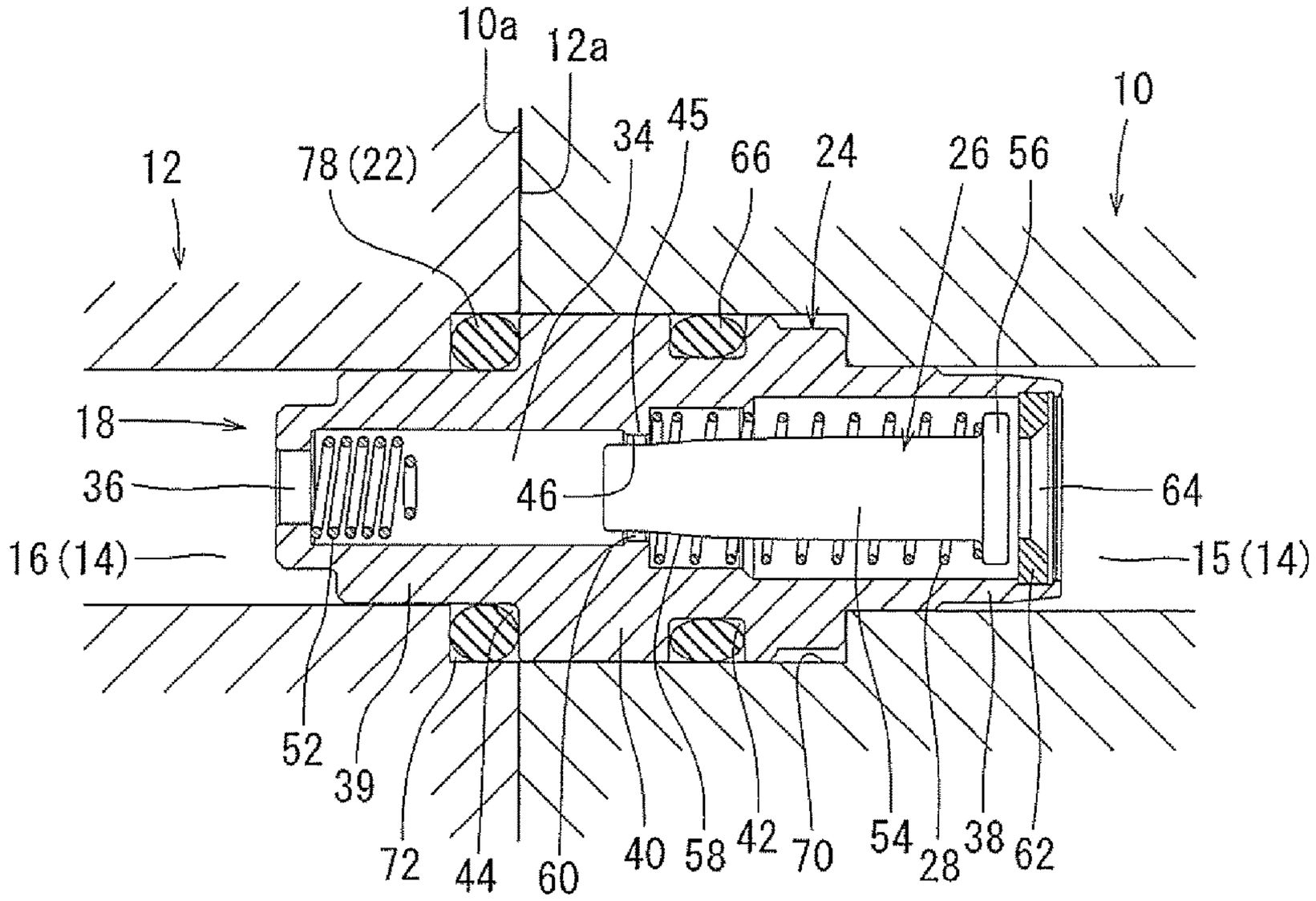

10a
12a
10
12
78 (22)
34
45
66
24
26
56
18
36
46
64
16 (14)
15 (14)
52
39
72
44
60
40
58
42
70
54
28
38
62

FIG. 1

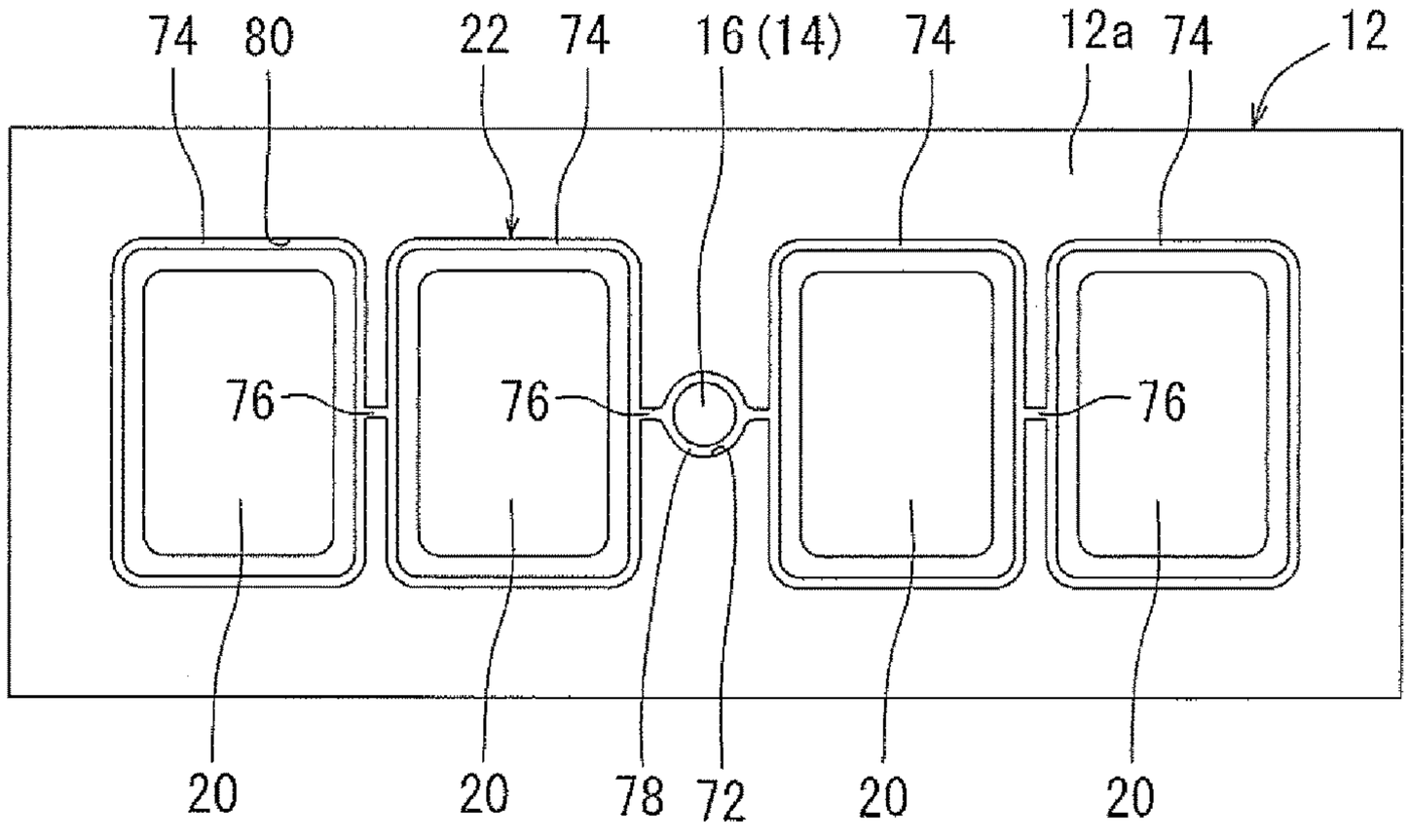

74
80
22
74
16 (14)
74
12a
74
12
76
76
76
20
20
78
72
20
20

FIG. 2

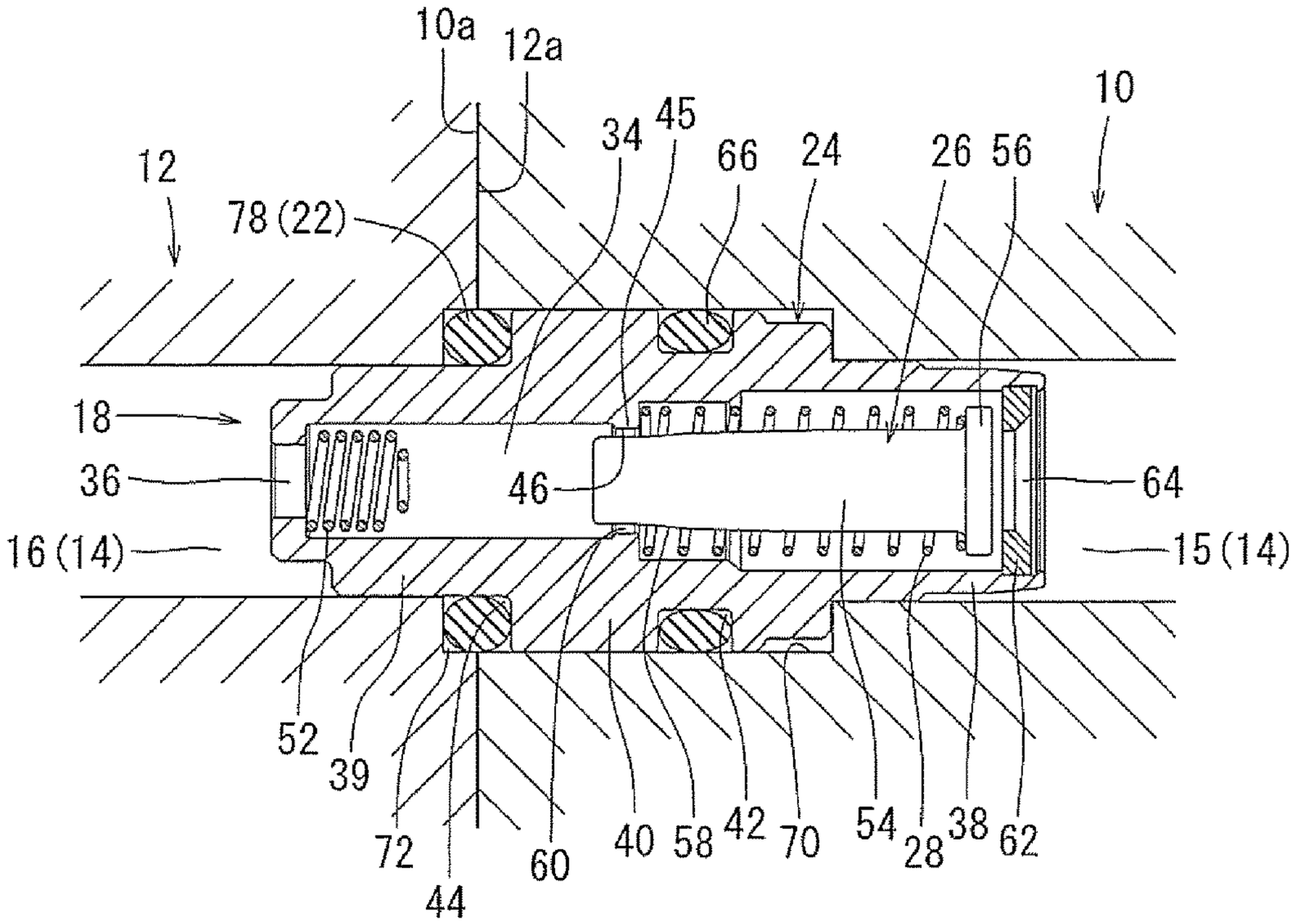

10a
12a
10
34
45
66
24
26
56
12
78 (22)
18
36
46
64
16 (14)
15 (14)
52
39
72
44
60
40
58
42
70
54
28
38
62

FIG. 3

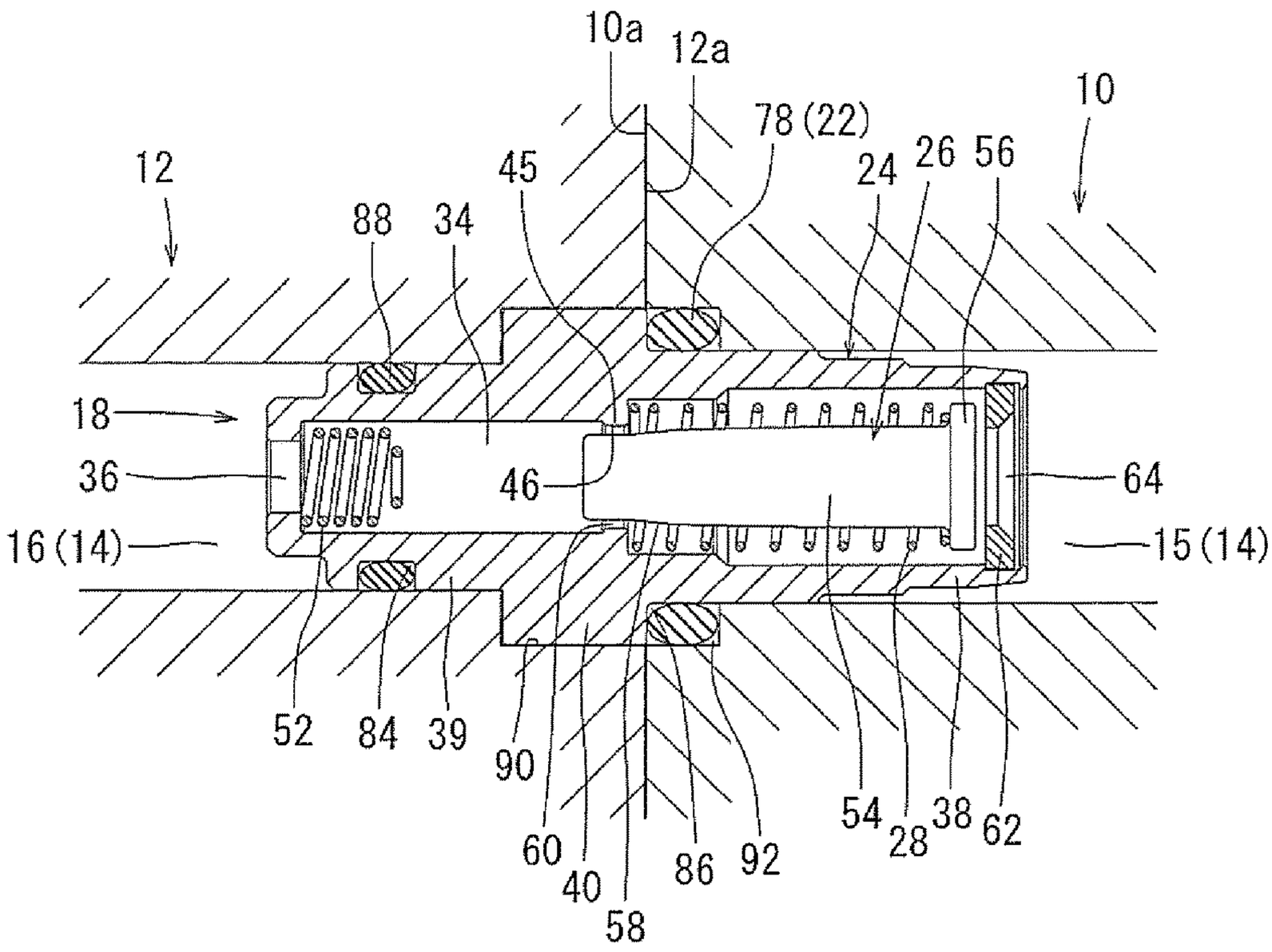

10a
12a
78 (22)
10
45
24
26
56
12
88
34
18
36
46
64
16 (14)
15 (14)
52
84
39
90
60
40
58
86
92
54
28
38
62

FIG. 4

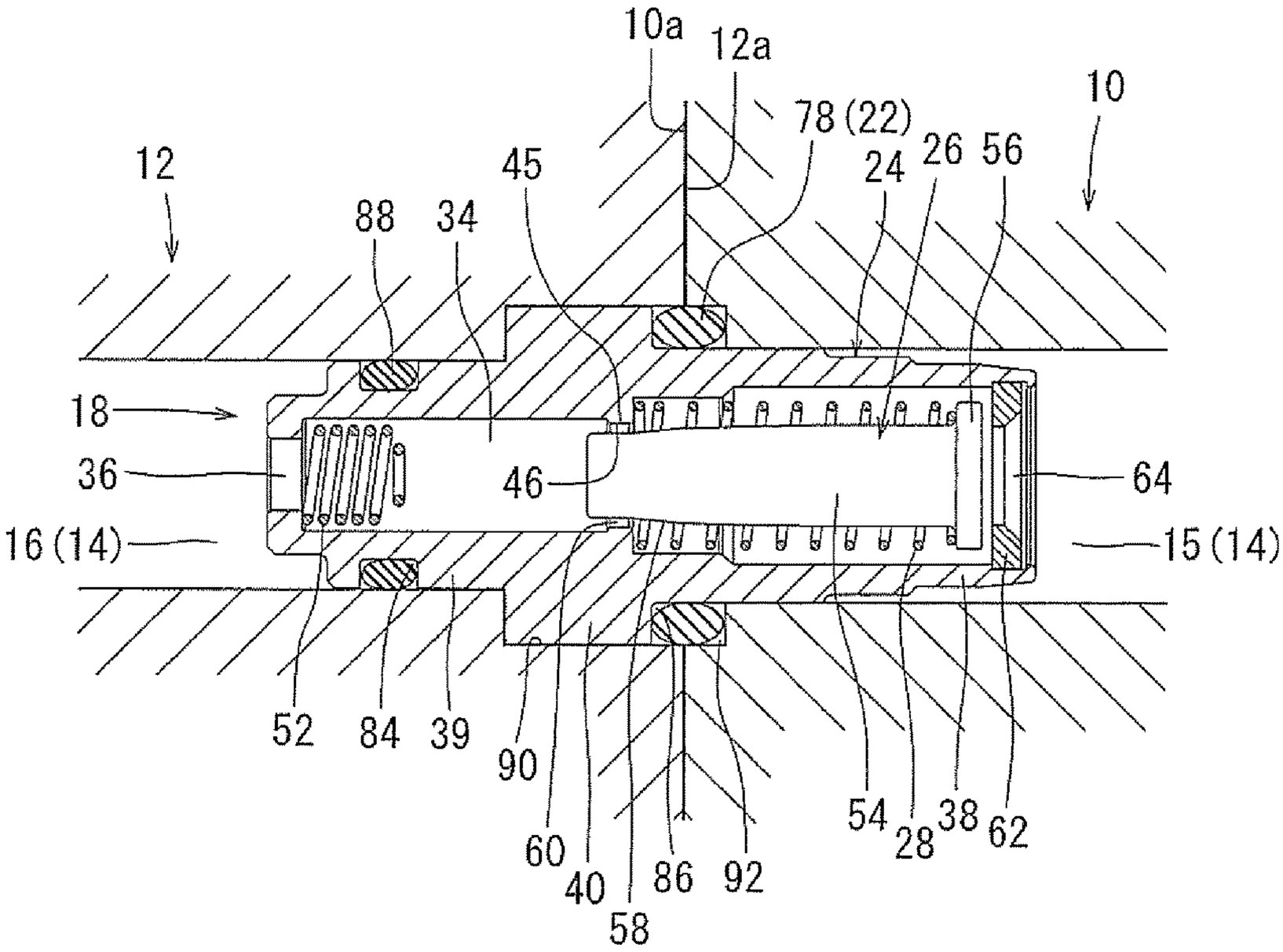


FIG. 5

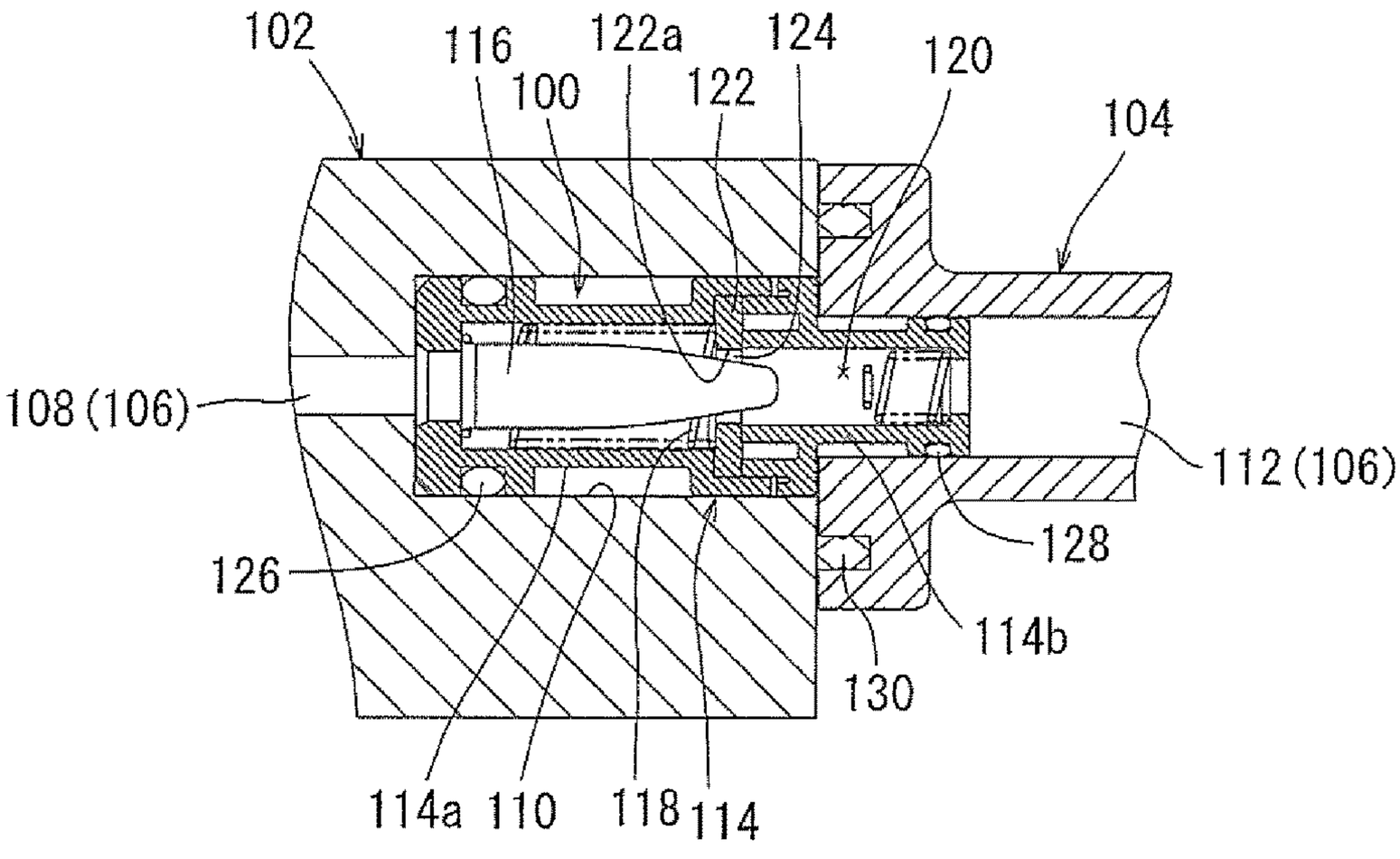


FIG. 6
PRIOR ART

POSITIVE CRANKCASE VENTILATION ("PCV") VALVE MOUNTING STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims priority to Japanese Patent Application Serial No. 2014-224163 filed on Nov. 4, 2014, the contents of which are incorporated herein by reference in their entirety for all purposes.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

BACKGROUND

The invention generally relates to a structure for mounting a positive crankcase ventilation valve (herein referred to as a "PCV" valve) to a cylinder head of an internal combustion engine, such as an engine for powering an automobile and/or any other vehicle engine. Further, the PCV valve may be mounted directly to an intake manifold of such an engine. Also, the PCV valve may direct and/or adjust flow of gas that may be recirculated from the engine and/or exhaust system of a vehicle, for example, back to the engine to enhance engine power delivery and efficiency.

FIG. **6** illustrates a known PCV valve mounting structure. As shown in FIG. **6**, a blow-by gas passage **106** includes an upstream-side passage portion **108** and a downstream-side passage portion **112** formed in a cylinder head **102** and an intake manifold **104** of the engine, respectively. The upstream-side passage portion **108** and the downstream-side passage portion **112** of the blow-by gas passage **106** may communicate with each other when the cylinder head **102** and the intake manifold **104** come into contact. A PCV valve **100** is mounted within the upstream-side passage portion **108** and the downstream-side passage portion **112** to extend therebetween. In detail, the PCV valve **100** may adjust flow rate of blow-by gas flowing though the blow-by passage **106**. A stepped recess portion **110**, with a diameter larger than the downstream-side passage portion **112**, is formed in the cylinder head **102** at an open end portion of the upstream-side passage portion **108**.

The PCV valve **100** has a valve case **114**, a valve member **116** positioned within and extending internally throughout the valve case **114** and a valve spring **118**. The valve case **114** includes a main case portion **114***a* and a sub-case portion **114***b*, both main and sub case portions **114***a* and **114***b* being made of resin. The main case portion **114***a* and the sub-case portion **114***b* are joined to each other in the axial direction (i.e., the left-to-right direction in FIG. **6**) to collectively define a gas passage **120**. A valve seat **122** made of metal is held between a right side end portion of the main case portion **114***a* and a left side end portion of the sub-case portion **114***b* to be coaxial with both the main and sub-case portions **114***a* and **114***b*. The valve seat **122** has an annular plate shape with a metering hole **122***a* formed therein. The valve member **116** enters into the gas passage **120**, so that a cross-sectional passage area (i.e. the open area) of the metering hole **122***a* of the valve seat **122** may be adjusted in response to the axial movement of the valve member **116**. The valve spring **118** biases the valve member **116** in an upstream-side direction (i.e. toward the left in FIG. **6**) with respect to the gas passage **120**. The downstream-side end of the PCV valve **100** (i.e., the right-side end of the sub-case portion **114***b* in FIG. **6**) is fitted into the open-ended portion of the downstream-side passage portion **112** of the intake manifold **104**. The remaining portion of the sub-case portion **114***b* is fitted into the stepped recess portion **110** of the cylinder head **102**, and the main case portion **114***a* is also fitted into the stepped portion **110**. A metering space **124** is defined as the region between the inner circumferential surface of the metering hole **122***a* of the valve seat **122** and the outer circumferential surface (i.e. metering surface) of the valve member **116**.

A first O-ring **126** seals the cylinder head **102** to the valve case **114** and may fit into a corresponding first O-ring groove (not shown in FIG. **6**) in the main case portion **114***a*. Similarly, a second O-ring **128** seals the intake manifold **104** to the valve case **114** and may fit into corresponding second O-ring groove (not shown in FIG. **6**) formed in the sub-case portion **114***b*. A gasket **130** is positioned between joint surfaces of the cylinder head **102** and the intake manifold **104** and is fitted into a corresponding gasket-receiving groove in the joint surface of the intake manifold **104**.

U.S. Patent Application Publication No. US2011/0203559 (also published as Japanese Laid-Open Patent Publication No. 2011-169258) generally discloses a PCV mounting structure similar to that shown in FIG. **6**.

In detail, the mounting structure shown in FIG. **6** involves two O-rings, i.e., the first O-ring **126** for sealing the cylinder head **102** to the valve case **114**, and the second O-ring **128** for sealing the intake manifold **104** to the valve case **114** as described above. Such an arrangement may result in difficulty in mounting the O-ring **126** and the O-ring **128** to the main case portion **114***a* and the sub-case portion **114***b*, respectively. Further, the operations for forming the O-ring grooves in the main and sub-case portions **114***a* and **114***b* are relatively involved and/or time-consuming. Thus, such an arrangement as described above may lead to an increase in costs associated with manufacturing and/or maintaining, for example, the mounting structure.

In view of the challenges discussed above, there is a need in the art for a PCV valve mounting structure with fewer components needed for operation, thus also contributing to a commensurate reduction in production costs associated with such a PCV valve mounting structure.

SUMMARY

A PCV valve mounting structure in accordance with an embodiment includes a PCV valve (positive crankcase ventilation valve) mounted to an engine cylinder head and to an intake manifold. The cylinder head may contact the intake manifold at a defined surface. The PCV valve mounting structure has a gas passage, i.e. a passage able to accommodate "blow-by" gas, with an upstream-side passage portion in the cylinder head and a corresponding down-stream-side passage portion in the intake manifold. The upstream and the down-stream-side passage portions may be in fluid communication when the cylinder head contacts and/or joins the intake manifold. The blow-by gas passage receives the PCV valve therein such that an upstream side portion of a valve case of the PCV valve is inside the upstream-side passage portion of the cylinder head. Further, the PCV valve may be inserted into the gas passage, as described here, such that a downstream side portion of the valve case of the PCV valve is within the down-stream-side passage portion of the cylinder head when the cylinder head and the intake manifold join together. Moreover, once inserted into the gas passage, the PCV valve may adjust flow of blow-by gas flowing through the blow-by gas passage. In an embodi-

ment, the PCV valve has a valve member movable longitudinally, i.e. along the length-wise direction of the PCV valve and/or gas passage, in response to a pressure variance between the upstream and downstream sides of the PCV valve that may occur while the PCV valve adjusts the cross-sectional area of the gas passage, i.e. as may be generally defined by a valve seat of the valve case. A gasket may be positioned on and/or at a surface where the cylinder head meets the intake manifold to prevent unwanted leakage of intake air through an intake air passage(s) formed in the engine. The gasket may have a seal portion positioned between the valve case of the PCV valve and either the cylinder head and the intake manifold to form a seal therebetween when the cylinder head contacts and/or joins the intake manifold.

In such an arrangement as described above, the gasket may seal the cylinder head to the intake manifold and, in an embodiment, the gasket may also seal the valve case of the PCV valve to either the cylinder head or the intake manifold. By allowing for the selection of the particular component to which the gasket forms a seal and/or seals, the overall number of components of the mounting structure may be minimized to accordingly reduce and/or control costs associated with manufacturing the mounting structure.

The PCV valve mounting structure may further include a seal ring that seals the valve case of the PCV valve to either of the cylinder head and the intake manifold.

In an embodiment, a receiving-side stepped portion may be formed on and/or at one of the joint surfaces of the cylinder head and the intake manifold. Similarly, an insertion-side stepped portion may be formed on the valve case of the PCV valve. In such an arrangement as described here, a seal portion of the gasket may be positioned between the receiving-side stepped portion and the insertion-side stepped portion to allow for relatively easy assembly and/or positioning of the seal portion between the valve case of the PCV valve and the cylinder head or the intake manifold.

In an embodiment, a seal member of the gasket may extend into both of the cylinder head and the intake manifold to allow for the simultaneous seal between the valve case of the PCV valve and the cylinder head, as well as between the valve case and the intake manifold.

The PCV valve may be positioned between two adjacent intake air delivery passages in the intake manifold. In detail, the blow-by gas passage may be formed in the engine between two adjacent delivery passages in the intake manifold or between two adjacent intake ports in the cylinder head in communication with the two adjacent delivery passages. With this arrangement, heat generated by operation the engine may be transmitted to the PCV valve as needed to thus prevent "icing" and/or "fixation," i.e. defined where a valve is fixed in a given position, of a valve member of the PCV valve against the wall of the gas passage when the engine is started in cold weather conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view of a side of a PCV valve mounting structure in accordance with a first embodiment;

FIG. **2** is a schematic view illustrating a surface, such as a joining and/or contact surface, of a cylinder head of an intake manifold in accordance with the first embodiment;

FIG. **3** is a cross-sectional view of a side of a PCV valve mounting structure in accordance with a second embodiment;

FIG. **4** is a cross-sectional view of a side of a PCV valve mounting structure in accordance with a third embodiment;

FIG. **5** a cross-sectional view of a side of a PCV valve mounting structure in accordance with a fourth embodiment; and

FIG. **6** is a cross-sectional view of a side of a PCV valve mounting structure according to prior art.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

A PCV valve mounting structure, in accordance with a first embodiment, will now be described with reference to FIGS. **1** and **2**. Referring to FIG. **1**, a blow-by gas passage **14** may have an upstream-side passage portion **15** positioned upstream from a down-stream side passage portion **16**, with respect to a direction of flow of blow by gas through the blow-by gas passage **14**. The upstream-side passage portion **15** may be formed in a cylinder head **10** of an engine. In detail, the downstream-side end of the upstream-side passage portion **15** may open at a joint surface **10***a* of the cylinder head **10**. The upstream-side end of the upstream-side passage portion **15** may be in fluid communication with a gas mixing and/or transference chamber (not shown in FIGS.) into which the blow-by gas may flow from combustion chambers of the engine. The mixing chamber, as described here, may be a "crank" chamber located in, for example, a crankcase of the engine or may be a separation chamber of an oil separator coupled with the crank chamber. Also, the cylinder head **10** may be made of aluminum alloy and an engine (not shown in the FIGS.) having a cylinder block configured to accept the cylinder head **10** may be a multi-cylinder engine, such as a four-cylinder engine.

The downstream-side passage portion **16** of the blow-by gas passage **14** may be formed in an intake manifold **12**. The upstream-side end of the downstream-side passage portion **16** may open at a joint surface **12***a* of the intake manifold **12**. The downstream-side end of the downstream-side passage portion **16** be in fluid communication with an intake air passage, such as one of distribution passages **20** (see FIG. **2**) formed in the intake manifold **12** or an internal space of a serge tank (not shown). Further, the intake manifold **12** may be made of resin.

The cylinder head **10** and the intake manifold **12** may be joined by a joining device (not shown in the FIGS.), such as a screw fastening device, a clipping device, and a snap-fitting device, such that the joint surface **10***a* of the cylinder head **12** and the joint surface **12***a* of the intake manifold contact with each other. In detail, the cylinder head **10** may be joined to and/or coupled with the intake manifold **12** such that all discussed interior passage portions (i.e. portions **15** and **16**) are aligned (i.e. in series) across a common axis extending lengthwise, i.e. horizontally as shown in FIG. **1**. A PCV valve **18** may be disposed in the blow-by gas passage **14** to extend between the passage portions **15** and **16**.

In an embodiment, the cylinder head **10** may be configured to define one or more of combustion chambers (not shown in the FIGS.), as well as intake and/or exhaust ports in correspondence with said chambers. Moreover, the intake manifold **12** may include a surge tank space (not shown in the FIGS.) and a plurality of delivery passages **20** (see FIG. **2**). The delivery passages **20** may be connected to the downstream-side of the surge tank space and may distribute intake air (i.e. fresh air from outside the air intake and/or engine) to each intake port of the cylinder head **10**.

FIG. **2** schematically illustrates the joint surface **12***a* of the intake manifold **12**, i.e. where the intake manifold **12** contacts the cylinder head **10**. As shown here, the delivery passages **20** may open at the joint surface **12***a*. Further, the

number of the delivery passages **20** may correspond to the number of engine cylinders (i.e., the number of the combustion chambers). In the embodiment shown here, four delivery passages **20** are provided, and their respective openings, are arranged in a row in the left-to-right direction as shown in FIG. **2**. The downstream-side passage portion **16** of the gas passage **14** may open at a central position, i.e. in between two of the openings of the delivery passages **20**. Moreover, a seal member or a gasket **22** shown in FIG. **2** may be positioned between the cylinder head **10** and the intake manifold **12** to form a seal therebetween.

As shown in FIG. **1**, the PCV valve **18** may have a valve case **24** that may generally enclose and/or define both a valve member **26** and a valve spring **28**. Further, the valve case **24** may be made from a suitable rigid material, such as a metal having a desirable heat conductivity including stainless steel, aluminum alloy, iron and/or any composite formed thereof, and may be formed as a cylindrical tube, for example. The valve case **24**, generally formed as a cylindrical tube as described here and/or as shown in at least FIG. **1**, may extend lengthwise in the axial direction, i.e. the left-to-right direction in FIG. **1**, to define a gas passage **34** through which gas may flow. In detail, the side (i.e. the right side as viewed in FIG. **1**) corresponding to the upstream-side of the gas passage **34** of the valve case **24** will may be referred to as a "base end side." Likewise, the side positioned opposite to the base end side, (i.e. left side as viewed in FIG. **1**) corresponding to the downstream side of the gas passage **34**, may be referred to as a "leading end side."

The inner circumferential surface of the valve case **24**, also a wall and/or surface of the gas passage **34**, may be formed with a gradient and/or stepped shape, such that the diameter of the inner circumferential surface of the valve case **24** gradually decreases from the base end side toward the leading end side. Moreover, the opening of the gas passage **34** on the leading end side may define a gas outlet **36**. Similar to that described above for the inner circumferential surface of the valve case **24**, the outer circumferential surface of the valve case **24** may also have a stepped shape, such that the valve case **24** has a first small diameter portion **38** positioned near and/or disposed on the base end side, a second small diameter portion **39** positioned near and/or disposed on the leading end side, and a large diameter portion **40** positioned near and/or disposed at an intermediate and/or center position between the first small diameter portion **38** and the second small diameter portion **39**. In detail, the large diameter portion **40** may be positioned nearer to the leading end of the valve case **24**. An insertion-side stepped portion **44** may be formed at a position where the outer circumferential surface of the second small diameter portion **39** intersects an end surface (i.e. a radially-surface) on the leading end side of the large diameter portion **40**.

An annular valve seat portion **45** (that may be shaped generally as a flange) may be formed on the inner circumferential surface of the gas passage **34** at a central position with respect to the axial direction of the gas passage **34**. In detail, the annular valve seat portion **45** may be positioned closer to the leading end of the valve case **24** rather than the base end thereof. The valve seat portion **45** may be centered at and/or on an axis extending lengthwise, i.e. from left-to-right, across the cylinder head **10**. The gas passage **34** may be centered around such an axis as described here and may have an inner diameter relatively smaller than that of the inner circumferential surface of the remaining portion of the gas passage **34**. The inner diameter of the valve seat portion **45** may define a metering hole **46**. A cushioning spring **52** may be disposed within the leading end side portion of the valve case **24**. In detail, in an embodiment, the cushioning spring **52** may be a metal coil spring and thus be able to elastically inhibit excessive and/or otherwise undesirable movement of the valve member **26** toward the downstream side (i.e. the left side in FIG. **1**). Further, the cushioning spring **52** may be inserted into the gas passage **34** via the base-end side opening of the valve case **24** until the cushioning spring **52** reaches an optimal and/or predetermined position, i.e. while still remaining within the leading end side portion of the valve case **24**, after passing though the metering hole **46**. Specifically, the cushioning spring **52** may be inserted into the gas passage **34** until touching and/or otherwise abutting a corresponding spring-receiving flange portion (not shown in FIG. **1**) on an inner circumference of the gas outlet **36** at the base-end portion of the valve case **24**.

In an embodiment, the valve spring **28** may be a metal coil spring and may be inserted into the gas passage **34** until the valve spring **28** contacts and/or otherwise abuts to the valve seat **45**. Thus, the valve seat **45** may function as a receiving portion for the valve spring **28**. In detail, valve spring **38** may be compressed to move and/or bias the valve member **26** toward the upstream side (right side in FIG. **1**) of the gas passage **34**.

The valve member **26** may be made of metal have a valve body portion **54** and a flange portion **56**. The valve body portion **54** may be formed in a relatively rounded (i.e. cylindrical) rod shape. The flange portion **56** may protrude radially outward from the base end (i.e. the right end of the cylinder head **10** as shown in FIG. **1**) of the valve body portion **54**. In an embodiment, the outer circumferential surface of the flange portion **56** may be polygonal, i.e. having defined sides. In detail, the flange portion may be formed to have sides of equivalent length and/or at uniform angles to one another, i.e. to form a "regular" polygonal shape. The valve member **26** may be inserted into the base end side opening of the valve case **24** and may be move in the axial direction (left-to-right direction in FIG. **1**) within the gas passage **34**. In detail, the valve body portion **54** may be movably fitted into the valve spring **28** until the flange portion **56** contacts an end surface on the side of the base end of the valve spring **28**. As described earlier, the polygonal outer circumferential surface of the flange portion **56** may slide and contact a side and/or wall surface of the gas passage **34**, such that a plurality of flow openings (i.e. arranged in the circumferential direction) may be defined between the outer circumference of the flange portion **56** and the wall surface of the gas passage **34** for allowing passage of the blow-by gas.

A metering surface **58** may be formed on the outer circumference of the leading end portion (i.e. toward downstream-side end portion as introduced and explained earlier) of the valve body portion **54**. In detail, the metering surface **58** may be tapered in a direction toward the leading end of the valve body portion **54** such that the leading end portion of the valve body portion **54** may insert into the metering hole **46** of the valve seat **45**, and a metering gap **60** may be defined between the inner circumferential surface of the metering hole **46** and the metering surface **58** of the valve body portion **26**. The valve body portion **26** may draw away from and/or otherwise retract from the metering hole **46** (or move in a direction toward the upstream side) (right side in FIG. **1**). As may be necessary to accommodate such movement of the valve body portion **26** as described here, an effective open area (i.e., the cross-sectional area) of the metering gap **60** may expand as needed. In comparison, as the valve body portion **26** advances into the metering hole **46**

(or moves in a direction toward the downstream side), the passage cross-sectional area of the metering gap **60** may decrease, i.e. such that the cross-sectional area of the metering gap **60** becomes smaller.

An annular removal-preventing member **62** may be fitted into the base-end side opening of the valve case **24** and may be fixed within the base end portion of the valve case **24** by a suitable fixation device and/or technique, such as by crimping. The inner circumference of the removal-preventing member **62** may define the gas inlet **64**. Moreover, an O-ring **66** may be fitted into a corresponding O-ring receiving groove **42** formed in the outer circumferential surface of the valve case **24**.

Components associated with mounting the PCV valve **18** into the cylinder head **10** will now be described in further detail. As shown in FIG. **1**, a stepped recess **70** may be formed at the joint surface **10***a* of the cylinder head **10** such that the open end of the upstream-side passage portion **15** is enlarged, i.e. "coaxially" enlarged about an axis extending lengthwise across the cylinder head **10**. The stepped recess **70** may be sized to accommodate and/or fit with the large diameter portion **40** of the valve case **24**. Further, a receiving-side stepped recess **72** may be formed at the joint surface **12***a* of the intake manifold **12** such that the open end of the downstream-side passage portion **16** is coaxially enlarged. Further, in an embodiment, the inner diameter of the stepped recess **70** may equal to or substantially equal to the inner diameter of the stepped recess **72**.

Referring now to that shown by FIG. **2**, the gasket **22** may have a plurality of first seal portions **74**, a plurality of connection portions **76** and a second seal portion **78**. Each of the first seal portions **74** may be generally formed in the shape of rectangle and surround corresponding delivery passages **20**. As described earlier, the number of the delivery passages **20** may correspond to the number of the engine cylinders. Thus, the number of the seal portions **74** may also correspond to the number of the engine cylinders. Each of the connection portions **76** may connect two adjacent seal portions **74**. In further detail, one of the connection portions **76** connecting two adjacent seal portions **74** generally located at the center of the intake manifold **12** (i.e. in the orientation shown in FIG. **2**) of the seal portions **74** may have the second seal portion **78**. In detail, the second seal portion **78** may have an annular shape to elastically fit with the insertion-side stepped portion **44** of the valve case **24** and with the receiving-side stepped portion **72** of the intake manifold **12** (see FIG. **1**). The gasket **22** may be inserted into a corresponding gasket fitting recess **80** formed at the joint surface **12***a*. Similarly, the second seal portion **78** may be fitted with the receiving-side stepped portion **72** at the same time the gasket **22** is fitted into the gasket fitting recess **80**. In an embodiment, the receiving-side stepped portion **72** may be defined by a part of the gasket fitting recess **80**. The second seal portion **78** may serve as a seal member and/or otherwise assist in sealing the PCV valve **18**.

Prior to joining the cylinder head **10** and the intake manifold **12** together as shown in FIG. **1** (i.e. such that the cylinder head **10** is pressed against the intake manifold **12**), the gasket **22** may be fitted into the gasket fitting recess **80** formed at the joint surface **12***a*, such that the seal portion **78** may be fitted with the receiving-side stepped portion **72** as described above. Next, the large diameter portion **40** of the valve case **24** may be fitted into the stepped recess portion **70**, and at the same time, the smaller diameter portion **38** on the base-end side of the valve case **24** may be fitted into the upstream-side passage portion **15** that may be in fluid communication with the stepped recess portion **70**. Resultantly, the gas inlet **64** of the valve case **24** may be aligned with the upstream-side passage portion **15** to allow for gas to pass as needed. Following, the cylinder head **10** and the intake manifold **12** may be jointed together, such that the small diameter portion **39** on the leading-end side of the valve case **24** may be fitted into the downstream-side passage portion **16** after passing through the second seal portion **78** of the gasket **22**. Thus, the gas outlet **36** of the valve case **24** may be aligned with the downstream-side passage portion **16** to allow gas to pass through the gas outlet **36** into the downstream-side passage portion **16** as needed. As a result, the PCV valve **18** may be inserted into and/or mounted within the cylinder head **10** and the intake manifold **12** to extend between the upstream-side passage portion **15** of the cylinder head **10** and the down-stream side passage portion **16** of the intake manifold **12**.

In the "mounted state" shown in FIG. **1** (i.e. in that the PCV **18** has been inserted into and/or retained within the cylinder head **10** as described above), the gasket **22** (see FIG. **2**) may seal the joint surface **10***a* of the cylinder head **10** and the joint surface **12***a* of the intake manifold **12** to prevent possible leakage of intake air in, for example, the upstream-side passage portion **15**. In addition, the second seal portion **78** of the gasket **22** may be positioned in between the insertion-side stepped portion **44** and the receiving-side stepped portion **72** of the intake manifold **12** to form a seal therebetween. Further, the O-ring **66** may be positioned between the valve case **24** and the inner circumferential surface of the stepped recess **70** of the cylinder head **10** to form a seal therebetween. Furthermore, the end surface on the base-end side of the large diameter portion **40** may press against and/or contact the bottom surface on the base-end side of the stepped recess **70** of the cylinder head **10**.

Upon starting the engine, a negative pressure produced in an intake passage (not shown in the drawings) of the intake manifold **12** may inside of a communication passage (not shown in the drawings) formed in the engine to facilitate the flow of the blow-by as may be needed for routine engine operation. Next, the blow-by gas may flow into passages **15** and **16**. Also, in an embodiment, fresh air (i.e. atmospheric air) suctioned into the intake manifold **12** may be redirected into a fresh air introduction passage (not shown in the FIGS.). During redirection and/or re-circulation of the blow-by gas throughout the various passages, i.e. passages **15** and **16** and/or the fresh air introduction passage as described here, the PCV valve **18** may operate according to load applied to the engine and/or the negative pressure (relative to ambient air) produced in the intake passage, such that the quantity of the redirected and/or re-circulated blow-by gas flowing from the upstream-side passage **15** to the down-stream-side passage **16** of the blow-by gas passage **14** may be controlled.

In detail, the valve member **26** of the PCV valve **18** may move to a position where force, such as a returning and/or biasing force, of the valve spring **26** applied to the valve member **26** may be adjusted to compensate for and/or counterbalance to the intake negative pressure or pressure variances in, for example, the passages **15** and **16**. Should a sudden reversal of gas flow direction occur, due to, for example a "misfire" and/or "backfire," defined as irregular fuel combustion in the combustion chambers of the engine, the valve member **26** may move toward the removal-preventing member **62** of the valve case **24** such that the flange portion **56** of the valve member **26** may be seated on the removal-preventing member **62** to close the gas inlet **64**. Accordingly, the blow-by gas passage **14** and the PCV valve

18 may be considered to constitute significant components of a blow-by gas recirculation system.

With the PCV valve mounting structure described above, the second seal portion **78** that may also be a part of the gasket **22**, may form a seal between the intake manifold **12** and the valve case **24** of the PCV valve **24**. Therefore, the number of components necessary for the PCV valve mounting structure may be minimized. Accordingly, the costs associated with manufacturing the gas recirculation system may be controlled.

Further, the O-ring **66** may form a seal between the cylinder head **10** and the valve case **24** of the PCV valve **18** to reliably prevent against unwanted leakage of blow-by gas from the passages **15** and **16** within the cylinder head **10**.

Moreover, the second seal portion **78** of the gasket **22** may be positioned between the receiving-side stepped portion **72** formed at the joint surface **12***a* of the intake manifold **12** and the insertion-side stepped portion **44** formed on the valve case **24**. Thus, the seal portion **78** may be assembled relatively easily as needed to seal the intake manifold **12** to the valve case **24**.

In addition, the downstream-side passage portion **16** of the intake manifold **12** may be positioned between two adjacent delivery passages **20** (see FIG. **2**). The delivery passages **20** may be in fluid communication with the intake ports (not shown in the FIGS.) of the cylinder head **10**. Alternatively described, the PCV valve **18** may be positioned between two adjacent intake ports. This arrangement may increase the quantity of heat able to be transmitted from the cylinder head **10** to the PCV valve **18**. This may inhibit unwanted adhesion and/or fixation of the valve member **26** that may be caused due to ice forming on and/or between the various components described here when the engine may be started in relatively cold temperatures.

A second embodiment will now be described with reference to FIG. **3**. The second embodiment is a modification of the first embodiment and thus shares many parts, components fixtures and/or the like with the first embodiment. Thus, like components are labeled with like reference numerals as the first embodiment, and a redundant description of the same will be omitted. The second embodiment differs from the first embodiment in that the second seal portion **78** of the gasket **22** extends into the open end of the stepped recess **70** of the cylinder head **10**. Alternatively put, the second seal portion **78** extends across a joint plane where the joint surface **10***a* of the cylinder head **10** and the joint surface **12***a* of the intake manifold **12** are joined together. Thus, the second seal portion **78** may form a seal between the intake manifold **12** and the valve case **24** of the PCV valve **24** and may also form a seal between the cylinder head **10** and the valve case **24** of the PCV valve **24**. For at least this reason, in particular as related to this (i.e. the second) embodiment, the O-ring **66** may be omitted.

A third embodiment will now be described with reference to FIG. **4**. As discussed above for the second embodiment, this (i.e. third) embodiment is a modification of the first embodiment and thus shares many parts, components, fixtures and/or the like with the first embodiment. Therefore, like components are labeled with like reference numerals as the first embodiment, and a redundant description of the same will be omitted. As shown in FIG. **4**, this (third) embodiment differs from the first embodiment primarily in that (i) the O-ring **66** may be replaced with O-ring **88** and in that (ii) the arrangement position of the second seal portion **78** of the gasket **22** is changed. In this connection as shown by FIG. **4**, the small diameter portion **39** on the leading-end side of the valve case **24** may include an annular groove **84** for accepting and/or fitting with the O-ring **88**. The annular groove **84** may be toward the center of the cylinder head **10** (relative to the axial direction) of the outer circumferential surface of the small diameter portion **39**. In addition, an insertion-side stepped portion **86** may be formed at a position where the outer circumferential surface of the small diameter portion **38** on the base-end side of the valve case **24** intersects the base end surface (i.e. the internal radial surface) of the large diameter portion **40**.

Also, a stepped recess **90** may be formed at the joint surface **12***a* of the intake manifold **12** such that the open end of the downstream-side passage portion **16** may be enlarged in the radial direction, i.e. coaxially enlarged. The stepped recess **90** may be sized to fit with the large diameter portion **40** of the valve case **24**. Likewise, receiving-side stepped portion **92** may be formed at the joint surface **10***a* of the cylinder head **10** such that the open end of the upstream-side passage portion **15** is coaxially enlarged. In this embodiment, the receiving-side stepped portion **92** may be axially opposed to the insertion-side stepped portion **86**. The inner diameter of the receiving-side stepped portion **92** may be equal to or substantially equal to the inner diameter of the stepped recess **90**.

Moreover, the gasket **22** may be fitted into the gasket fitting recess **80** formed at the joint surface **12***a* of the intake manifold **12**, similar to that shown and discussed in connection with the first embodiment. However, in the third embodiment, the gasket **22** may be fitted into a gasket fitting recess (not shown in the FIGS.) formed at the joint surface **10***a* of the cylinder head **10** and configured to have a shape similar to that of the gasket fitting recess **80**. Thus, each of the seal portions **74** may surround the open end of the corresponding intake port of the cylinder head **10**, i.e. similar to that shown by FIG. **2**.

With this (i.e. third) embodiment, prior to joining the cylinder head **10** and the intake manifold **12** together, the gasket **22** may be fitted into the gasket fitting recess formed at the joint surface **10***a* of the cylinder head **10**. At the same time, the second seal portion **78** of the gasket **22** may be fitted into the receiving-side stepped portion **92** of the cylinder head **10**. Alternatively, the large diameter portion **40** of the valve case **24** may be fitted into the stepped recess portion **90** of the intake manifold **12**, and at the same time, the small diameter portion **39** on the leading end side of the valve case **24** may be fitted into the downstream-side passage portion **16** on the downstream side of the stepped recess portion **90**. Thus, the gas outlet **36** of the valve case **24** may be aligned with the downstream-side passage portion **16**. Thereafter, the cylinder head **10** and the intake manifold **12** may be joined together, such that the small diameter portion **38** on the base-end side of the valve case **24** may be fitted into the upstream-side passage portion **15** after passing through the second seal portion **78** of the gasket **22**. Thus, the gas inlet **64** of the valve case **24** may be aligned with the upstream-side passage portion **15** to allow for the PCV valve **18** to be mounted within the cylinder head **10** and the intake manifold **12**. In detail, the PCV valve **18** may extend between the upstream-side passage portion **15** of the cylinder head **10** and the down-stream side passage portion **16** of the intake manifold **12**.

While the PCV **18** is mounted within the cylinder head **10** and the intake manifold **12** as shown in FIG. **4**, similar to the first embodiment, the gasket **22** (see FIG. **2**) may form a seal between the joint surface **10***a* of the cylinder head **10** and the joint surface **12***a* of the intake manifold **12**. In addition, the second seal portion **78** of the gasket **22** may be positioned between the insertion-side stepped portion **86** of the valve

case **24** and the receiving-side stepped portion **92** of cylinder head **10** so as to form a seal therebetween. Further, the end surface on the leading-end side of the large diameter portion **40** may abut and/or otherwise contact or slightly spaced from the bottom surface on the base-end side of the stepped recess **90** of the intake manifold **12**.

The PCV valve mounting structure of this (i.e. third) embodiment, similar to the first embodiment, provides the second seal portion **78**, that is a part of the gasket **22**, to form seal between the intake manifold **12** and the valve case **24** of the PCV valve **24**. Therefore, the number of components necessary for the mounting structure may be minimized to thus reduce costs associated with manufacturing of the gas recirculation system.

Further, the O-ring **88** may seal the intake manifold **12** to the valve case **24** of the PCV valve **18** to prevent potential leakage of the blow-by gas.

Moreover, the second seal portion **78** of the gasket **22** may be positioned between the receiving-side stepped portion **92** formed at the joint surface **10***a* of the cylinder head **10** and the insertion-side stepped portion **86** formed on the valve case **24**. Thus, the second seal portion **78** may be easily assembled for sealing between the cylinder head **10** and the valve case **24**.

A fourth embodiment will now be described with reference to FIG. **5**. This embodiment is a modification of the third embodiment. Therefore, like components are labeled with like reference numerals as the third embodiment, and a redundant description of the same will be omitted. The fourth embodiment is different from the third embodiment in that the second seal portion **78** of the gasket **22** extends into the open end of the stepped recess **90** of the intake manifold **12**. Alternatively described, the second seal portion **78** extends across a joint plane between the cylinder head **10** and the intake manifold **12**. Thus, the second seal portion **78** may seal the cylinder head **10** to the valve case **24** of the PCV valve **24** and may also seal the intake manifold **12** to the valve case **24**. For at least this reason, in particular as shown for this (fourth) embodiment, the O-ring **88** may be omitted.

The above-described embodiments may be modified further in various ways. For example, the embodiments have been described for the PCV valve mounting structure for mounting one PCV valve to one blow-by gas passage connected to the engine. However, for example, if a plurality of blow-by gas passages are arranged in parallel with each other are also connected to the engine, a plurality of PCV valve mounting structures may be incorporated and/or configured with the blow-by gas passages as desired.

In an embodiment, the valve case **24** may be made of resin instead of metal. Further, at least one of the valve portion **26**, the valve spring **28** and the cushion spring **52** may be made of resin.

Although the blow-by gas passage **14** into which the PCV valve **18** may be mounted is located at a position between the delivery passages **20** or between the intake ports, the blow-by gas passage **14** may be located, for example, on the outer peripheral side of the joint surfaces.

Further, the cross-sectional shape of the seal portion **78** of the gasket **22** may not be limited to a circular shape but may be a rectangular shape or any other shape. Also, the number of the first seal portions **74** of the gasket **22** may not be limited to four but may be one, two, three or five or more to correspond to the number of the delivery passages **20**. Even further, the O-rings **66** and **68** may be replaced with seal rings having a rectangular cross sectional shape or any other cross sectional shape.

The various examples described above in detail with reference to the attached drawings are intended to be representative and thus not limiting. The detailed description is intended to teach a person of skill in the art to make, use and/or practice various aspects of the present teachings and thus is not intended to limit the scope of the invention. Furthermore, each of the additional features and teachings disclosed above may be applied and/or used separately or with other features and teachings to provide improved PCV valve mounting structures, and/or methods of making and using the same.

Moreover, the various combinations of features and steps disclosed in the above detailed description may not be necessary to practice the invention in the broadest sense, and are instead taught to describe representative examples. Further, various features of the above-described representative examples, as well as the various independent and dependent claims below, may be combined in ways that are not specifically and explicitly enumerated in order to provide additional useful embodiments of the present teachings.

All features disclosed in the description and/or the claims are intended to be disclosed as informational, instructive and/or representative and may thus be construed separately and independently from each other. In addition, all value ranges and/or indications of groups of entities are also intended to include possible intermediate values and/or intermediate entities for the purpose of original written disclosure, as well as for the purpose of restricting the claimed subject matter.

What is claimed is:

1. A positive crankcase ventilation (PCV) valve mounting structure for mounting a PCV valve to an engine cylinder head and to an intake manifold, wherein the engine cylinder head contacts the intake manifold at a joint surface of the cylinder head and a joint surface of the intake manifold, the PCV valve mounting structure comprising:

a blow-by gas passage with an upstream-side passage portion in the cylinder head and a down-stream-side passage portion in the intake manifold;

wherein the upstream-side passage portion and the down-stream-side passage portion allow for fluid communication when the cylinder head and the intake manifold are joined together;

wherein the blow-by gas passage is configured to receive the PCV valve therein such that an upstream side portion of a valve case of the PCV valve is positioned within the upstream-side passage portion and that a downstream side portion of the valve case of the PCV is positioned within the down-stream-side passage portion when the cylinder head and the intake manifold are joined together;

wherein the PCV valve adjusts a flow of blow-by gas flowing through the blow-by gas passage; and

a gasket positioned between the joint surface of the cylinder head and the joint surface of the intake manifold;

wherein the gasket includes a seal portion positioned between the valve case of the PCV valve and one of the cylinder head and the intake manifold, the seal portion contacting the valve case and contacting one of the cylinder head and the intake manifold to form a seal between the valve case and one of the cylinder head and the intake manifold when the cylinder head and the intake manifold are joined together.

2. The PCV valve mounting structure of claim **1**, further comprising:

a seal ring that seals the valve case of the PCV valve to the other of the cylinder head and the intake manifold.

3. The PCV valve mounting structure of claim **1**, wherein:

a receiving-side stepped portion is formed at the joint surface of one of the cylinder head and the intake manifold;

an insertion-side stepped portion is formed on the valve case of the PCV valve; and

the seal portion of the gasket is interposed between the receiving-side stepped portion and the insertion-side stepped portion.

4. The PCV valve mounting structure of claim **1**, wherein a seal member of the gasket is arranged to extend into the cylinder head and the intake manifold.

5. The PCV valve mounting structure of claim **1**, wherein:

the seal portion of the gasket is arranged to extend across the joint surface of the cylinder head and the joint surface of the intake manifold.

6. The PCV valve mounting structure of claim **1**, wherein the PCV valve is arranged between two adjacent delivery passages formed in the intake manifold for distributing intake air.

7. The PCV valve mounting structure of claim **1**, wherein the seal portion is formed integrally with the gasket.

8. The PCV valve mounting structure of claim **1**, wherein the engine includes at least one intake air delivery passage extending across the joint surface of the cylinder head and the joint surface of the intake manifold; and

wherein the gasket is configured to prevent leakage of intake air from the engine via the at least one intake air delivery passage.

9. A positive crankcase ventilation (PCV) valve mounting structure for mounting a PCV valve to an engine cylinder head and to an intake manifold, the engine cylinder head and the intake manifold being joined together at a joint surface of the cylinder head and a joint surface of the intake manifold, the PCV valve mounting structure comprising:

a blow-by gas passage with an upstream-side passage portion in the cylinder head and a down-stream-side passage portion in the intake manifold;

wherein the upstream-side passage portion and the down-stream-side passage portion allow for fluid communication upon joining the cylinder head to the intake manifold;

wherein the blow-by gas passage is configured to receive the PCV valve therein such that an upstream side portion of a valve case of the PCV valve is positioned within the upstream-side passage portion and that a downstream side portion of the valve case is positioned within the down-stream-side passage portion when the cylinder head and the intake manifold are joined together;

wherein the PCV valve is configured to adjust a flow of blow-by gas flowing through the blow-by gas passage; and

a seal accommodation space in the blow-by gas passage between an outer circumferential surface of the valve case of the PCV valve and an inner circumferential wall of at least one of the upstream-side passage portion and the downstream-side passage portion;

wherein at least a part of the seal accommodation space is positioned proximal to or across the joint surface of the cylinder head and the joint surface of the intake manifold, so that the at least a part of the seal accommodation space is open to at least one of the joint surfaces; and

a first seal member disposed within the seal accommodation space such that the first seal member prevents leakage of the blow-by gas from the blow-by gas passage to an outside of the engine between the joint surface of the cylinder head and the joint surface of the intake manifold.

10. The PCV valve mounting structure of claim **9**, wherein:

the seal accommodation space is defined between a first stepped portion formed at the joint surface of one of the cylinder head and the intake manifold and a second stepped portion formed on the outer circumferential surface of the valve case of the PCV valve.

11. The PCV valve mounting structure of claim **9**, wherein:

the engine includes at least one intake air delivery passage extending across the joint surface of the cylinder head and the joint surface of the intake manifold;

the first seal member is connected to a second seal member;

the second seal member is positioned between the joint surface of the cylinder head and the joint surface of the intake manifold and configured to prevent leakage of air.

12. The PCV valve mounting structure of claim **11** wherein the second seal member is formed integrally with the first seal member.

* * * * *